Roadmap to Bridge Energy Security in Canada to Ensure Equity during Canada's Energy Transition Through SMR and Microgrid Usage in Northern and Arctic Communities

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Introduction:

In recent years, Canada has made several commitments on global stages and promises to achieve net-zero emissions by 2050. Accordingly, it has made significant investments in various industries that range from clean electricity & electrification to eco-friendly innovations. However, these commendable aspirations, made on a national scale, are restrained by immense regional inequality. Numerous Northern and Arctic communities, owing to their extreme weather conditions, rely greatly on diesel for heating and electricity. However, the supply of the same has been becoming more and more difficult. The preponderant obstacle stymying the aforementioned commitments here is that Diesel is firstly carbon-intensive, which directly opposes the previously mentioned aspirants to head towards a low-carbon economy. Furthermore, it is also expensive and susceptible to supply disruptions, which make its demand logistically challenging in these isolated areas. Due to this, a persistent energy disparity has cropped up at the core of Canada's transition.

Shifting our focus to the Southern provinces, the demand for electricity is only continuously rising throughout due to a myriad of factors like electrification, population growth, and industrial decarbonization. It is thus imperative to close this gap, and as time continues, it will only become not just more critical but also much more difficult. As simple as it may sound, the Northern communities cannot just "plug into" the larger clean grid; it is not just geographically but also economically insurmountable to expand long-distance transmission to these remote areas. Rather, there is an urgent need for a diversified and localized strategy to expedite Canada's energy transition.

Some feasible and promising solutions do exist, such as gradually replacing diesel with a mix of renewable microgrids and Small Modular Reactors (SMRs). On one hand, microgrids, which combine solar, wind, and storage, are a great way of improving flexibility and community resilience. On the other hand, SMRs offer low-emission baseload power that is dependable and reliable for challenging locations (especially remote ones). By combining these two technologies, Canada can effectively pave the way to cut down emissions and lower long-term energy costs. Moreover, paramountly, this would enable Northern communities to actively engage in Canada's clean energy future rather than staying on the periphery. This would allow Canada to meet its environmental commitments in a geographically equitable and sustainable manner.

Context & Bottlenecks: The Grid Expansion Dilemma:

Ontario's government has signalled a strong commitment to expanding clean transmission infrastructure, aiming to augment the productive capacity of northern regions, provide essential capacity for community and infrastructural growth, and reduce GHG emissions and the fiscal burdens of diesel dependency.

The recent completion of the Wataynikaneyap project- a $1.9 billion CAD line development project conducted with an equity partnership alongside 24 First Nations, Fortis Inc. and other private investors- has established 1,800 km of transmission lines and 22 substations, connecting 17 remote First Nations communities to the provincial grid (1); with an expected elimination up to 6.6 million tonnes of greenhouse gas emissions annually—equivalent to removing nearly 35,000 cars from the road—while contributing over $1 billion to Ontario's GDP. (2) The recent Greenstone Transmission Line priority declaration in January signals further political will- supporting the "Ring of Fire" region, enabling mining development and reshoring Ontario's supply chains. It targets an 81% increase in energy demand for northern Ontario and the Ring of Fire by 2050. Hydro One's equity model will ensure 50% Indigenous ownership, with the project expected to be completed in 2032. (3)

While demonstrating significant progress, these expansions address a limited portion of Ontario's north, reaching near-north communities as infrastructural extensions, while communities further north remain unconnected. The Northern Ontario Connection Study notes 10 notable Indigenous and far north communities not currently designated for connection, as well as smaller population hotspots between northern hubs. (4). While communities like those along the Greenstone corridor are within range of existing transmission infrastructure, are accessible and more densely populated, the near north faces significant infrastructure expansion barriers.

The James Bay lowlands and far north communities are geographically isolated at a scale that fundamentally alters capital cost projections (5). Beyond roughly 500–600 km from a stable grid anchor, the engineering costs of maintaining power quality on a single radial line become prohibitive, especially given the dispersed nature of communities at great distances from each other (6). Furthermore, permafrost has historically proven challenging for the development of larger infrastructure such as transmission towers- (7) (8) this issue is accelerated by thawing due to warming regional temperatures (9). Lastly, high-voltage transmission lines in the far north face ice loading, freezing rain, and wind conditions that regularly exceed design tolerances built for southern climates (10). Engineering for structural resilience is capital-intensive and generates elevated ongoing operations and maintenance expenditures, further compounded by limited accessibility and constrained road and aviation infrastructure; the challenges faced by near-north development are unlikely to be solved by the same blueprint as the near-north. These communities require a more centralized, resilience-centred grid option rather than waiting for expansionary policies.

The policy framework governing line expansion and microgrid decisions remains fragmented. In Ontario, transmission expansion is governed by the *Electricity Act, 1998,* and the *Ontario Energy Board Act* (11), with priority project declarations under section 96.1 enabling accelerated approvals—mechanisms applied to both Wataynikaneyap and Greenstone 12). At the federal level, Indigenous Services Canada administers diesel subsidy programs, while Natural Resources Canada supports community renewable energy projects. Various single-window programs, joint boards and grants may be leveraged to apply a unified and streamlined approach to Northern development, such as the recent Wah-ila-toos initiative (13).

Comparatively, Quebec’s vertically integrated hydro Quebec model allows cross-subsidization for remote communities as a public utility obligation, facilitating key projects such as La Romaine and the Nunavik Tarquti renewable partnerships- smaller regional projects that Ontario has no equivalent model for (14). The Northwest Territories illustrates alternative policy-leveraging development, specifically around mining, leading to stalled infrastructural projects due to project delays (Mackenzie Valley corridor studies) (15) The grid consequences are tangible: the Northwest Territories Power Corporation recorded a 30% increase in power outages in 2025, with only eight of the NWT's 33 communities on one of two main grids (16). Aging systems are being pushed beyond their intended life while small rate bases cannot finance rebuilds (17).

Learning from this, Ontario must clearly distinguish grid-viable from grid-inviable communities and legislate specific funding pathways for both — rather than defaulting to a Near-North umbrella model that leaves the most remote communities waiting on development that may never materialize, or depend on government financial support.

Looming Grid Strain: Electrification, Mining, and Northern Settlement:

Ontario's grid operator expects a major growth in long-run energy demand. In IESO's 2026 Annual Planning Outlook, electricity demand in the Canadian province of Ontario is expected to rise from 152 TWh in 2026 to 250 TWh in 2050, a 65% increase in the basic reference case. Notably, in the high-demand case, likely given an increasing population and federal infrastructure projects, demand is expected to reach 297 TWh, a 92% increase. ISEO links such growth to electrification, EV uptakes, data centres, and industrial expansion (18).

In the 2025 Annual Planning Outlook, Ontario's transportation-sector electricity demand is projected to rise from 3 TWh in 2026 to 44 TWh in 2050, an increase of approximately 1367%, or 41 TWh. This is significant, showing that the transportation sector will face an exponential rise in electricity demand in the coming years, placing a major strain on existing grid infrastructure designed to handle only minor transportation demand (18).

Dividing the 44 TWh demand from the transportation industry in 2050 by the number of hours in a year, it is found that Ontario's transportation sector will draw approximately 5.0 GW average continuous load. This is equivalent to a large new baseload block on the Ontario electricity system. This is significant since a baseload block is a continuous load that draws from the grid 24 hours a day, for 7 days a week. Currently, the 41 TWh increase in demand is 27% of Ontario's 2026 electricity base of 152 TWh. This demonstrates that the electricity demand from Ontario's transportation transition is equivalent to nearly a third of the province's total load. Such a reliability issue is sharper since EV charging is not flat. IESO predicts that EV charging is a major reason Ontario's grid will become a dual-peaking system by 2030, indicating significant grid strain (18).

Such a grid pressure is policy-driven, with Canada targeting 100% zero-emission new light-duty vehicle sales by 2035, including 20% by 2026 and 60% by 2030 (19). On top of this, federal infrastructure projects, including High Speed Rail (HSR) like Alto, would run at 300 km/h on 1000 km of electrified track between Quebec City and Windsor. While ISESO has pledged to monitor Alto's details as the project matures (20), it is clear that HSR will add a new fixed electric load on the same Ontario-Quebec system under strain by a dominant electric vehicle load.

Ontario's northern energy security challenges are further intensified by industrial buildout that is electricity-intensive. IESO's short-term outlook identifies industrial mineral extraction and processing as a major source of near and long-term demand growth, while commercial data centres and EV-related activity as significant load drivers in the mid-term. As a result, mining, processing, and digital infrastructure are competing for the same grid capacity (18). This pressure is visible in the northern regions. According to the Ontario Government, electricity demand in Northern Ontario will increase by 81% by 2050, with new transmission infrastructure framed as mining-enabling infrastructure, alongside community support (21). The proposed Greenstone Transmission Line, for example, is expected to unlock 250-700 MW of additional energy generation capacity, translating to 3.07-6.13 TWh of electricity per year, significant in northern-energy terms (21).

Similar logic applies to the Ring of Fire, where Ontario is accelerating the development of 500km+ of all-season roads, with expected construction to start in June 2026 and roads beginning to open by November 2030. This links transportation access and transmission expansion to critical mineral extraction and regional growth (22). Lithium development demonstrates how quickly such loads accumulate. For example, the Whabouchi mining project in northern Quebec has assessed power supply options for 7.5 MW demand, equivalent to an annual 65.7 GWh of demand for a single remote site. When factoring in downstream refining, worker accommodations, and transport infrastructure, a single remote plant in Northern Ontario can place a sizable strain on the grid (23).

Overall, it is evident that northern infrastructure projects, coupled with rising EV demand, will place a significant strain on pre-existing grid capacity for Ontario.

Technological Levers: SMRs and Microgrids as the Path Forward:

While a large-scale grid-expansion may be financially, and politically, unfeasible due to the heavy costs and high maintenance required to maintain traditional grid infrastructure in sub-arctic conditions, Small-Modular-Reactors (SMRs) and microgrid technology offer a way to ensure northern energy security as the primary Ontario grid observes a significant rise in demand.

Small-Modular Reactors are specialized, compact, nuclear fission reactors that have roughly one-third the power capacity of a full nuclear reactor, despite taking up significantly less space. As a result, SMRs are being explored as options for remote communities, where climate and population considerations make a full facility impractical, and support for strained grids. Furthermore, a microgrid is a localized, independent, power grid that generates, stores, and distributes electricity over a given, localized, area. When put together, SMR-driven microgrids provide a strong solution to ensure and strengthen northern and remote energy security. Due to the strong power-generating capacity and compact size of SMRs, leveraging them to power microgrids would provide northern communities with a reliable energy solution independent of the Ontario grid, freeing up provincial resources to support the electric-vehicle transition.

A tiered system centered upon microgrids and SMRs is a credible technical pathway to achieving northern energy security. Natural Resources Canada reports that over three quarters of Canada's 250 remote communities rely on diesel generation for power (24), while another study notes that 292 communities across the country face high fuel costs and have weak resilience to disruptions in supply. The Clean Energy for Rural and Remote Communities program has committed over CAD $220 million over 8 years to reduce diesel dependence (25), demonstrating that the federal government views remote energy systems to be strategic infrastructure issues, and not a local utility problem. Clearly, the political and financial backing is present to fund modular, compact, technologies that can power remote communities. To further the cause of microgrids, Natural Resources Canada has linked smart-grid technology, such as the one seen in British Columbia's Hartley Bay, to increased renewable output and energy-cost savings for local residents (26), further demonstrating the positive impacts of microgrids on the energy transition and the financial health of local residents.

The resilience case is strong for SMRs and microgrids. Canada's emergency management framework warns of the increase and severity of disasters, including wildfires, floods, and infrastructure disruption due to climate-related events. In July 2026, wildfires in Northwestern Ontario destroyed multiple transmission lines to northern communities. This underscores the importance of microgrids as even when communities are connected to larger provincial systems, independent local infrastructure, specifically SMRs and microgirds, provide backup power during grid failures, fuel shortages, or climate-driven natural disasters. As such, SMRs and microgrids are more than decarbonization tools, they are energy-security assets that ensure consistent electricity access to northern residents, critical to access services in a technologically reliant world.

Equitable Transition: Indigenous Partnership and Consent:

The success of the energy transition in Northern and Arctic Canada depends on the acknowledgement and alignment with the needs of different communities across Canada's geography. Indigenous nations are disproportionately affected by diesel reliance, facing higher energy costs and health and environmental risks. Nonetheless, they are key stakeholders in the transition, as their consent and rights must be guaranteed for decision-making. Thus, the installation of small modular reactors (SMRs) and microgrids must prioritize co-development, equity and ownership throughout the process, rather than solely consultation with Indigenous communities.

Majority Indigenous ownership in transmission projects has shown that aligning infrastructure development with Indigenous rights, priorities, and stewardship leads to more successful projects. Adopting this framework for deploying energy technologies, especially SMRs and microgrids, is a step forward toward ensuring that the benefits of these energy systems remain local, building autonomy for a resilient long-run future.

The benefits of transitioning away from diesel are significant, improving health, social and economic outcomes. In terms of public health, the lower reliance on diesel as a source of energy directly reduces air and water pollution and, hence, it decreases the chance of exposure to toxins. At the same time, the diversification of electricity sources promotes local industries and connectivity across remote communities, leaving aside exploitative resource extraction.

Overall, placing Indigenous partnership and consent at the core of Canada's energy transition leads to more fair and effective results, limiting risks during implementation, enhancing the long term-sustainability of energy projects, and guaranteeing a resilient and inclusive energy future.

Financial Feasibility & Strategic Policy Pathways:

The current paradigm of diesel reliance in the Far-North represents an unsustainable sunk cost. At present, energy security in remote communities is artificially maintained through perpetual federal and provincial subsidies required to transport and store diesel fuel. For context, the federal government spends between $300 million and $400 million annually on diesel subsidies for remote communities (27). This approach leaves communities completely exposed to volatile fuel markets and yields no long-term infrastructure equity. Furthermore, while extending traditional grids may appear cost-effective in Near-North modelling, the true lifecycle capital and maintenance expenditures for the Far-North are financially prohibitive. Engineering single radial lines across hundreds of kilometres of thawing permafrost and extreme weather zones dramatically inflates both upfront and ongoing maintenance costs, as climate-driven permafrost degradation compromises structural integrity (28). In contrast, while Small Modular Reactors (SMRs) and advanced microgrid systems require a substantial initial capital expenditure, their long-term operational expenditure is markedly lower. When amortised over a standard 60-year operational lifespan, these decentralised facilities provide a vastly superior return on investment, transforming continuous subsidy drains into stable, long-term energy equity (29).

A primary institutional barrier to mobilising this capital is the highly fragmented nature of current policy and regulatory frameworks. Presently, funding and approvals are severely siloed: Indigenous Services Canada (ISC) manages diesel subsidy programmes, Natural Resources Canada (NRCan) oversees clean energy transition grants, and the Canadian Nuclear Safety Commission (CNSC) regulates SMR deployment (30). To overcome this bottleneck, the establishment of a unified, cross-jurisdictional task force is required. By formally aligning NRCan, ISC, the CNSC, and provincial grid operators like Ontario’s IESO, governments must create a streamlined, single-window funding and licensing pathway. This institutional coordination is not merely an administrative exercise; it is a critical lever designed to reduce bureaucratic delays, redirect diesel subsidies into upfront project capital, de-risk early-stage development, and provide the regulatory certainty required to attract private investment and empower Indigenous equity partnerships.

To tangibly overcome the initial capital barriers, governments must incentivise innovative market mechanisms, primarily the "anchor tenant" model. By leveraging Power Purchase Agreements (PPAs), highly profitable industrial loads such as critical mineral mining in the Ring of Fire can serve as the primary financial anchor for an SMR. This guarantees a steady revenue stream for the utility provider while cross-subsidising the energy costs for neighbouring Indigenous communities in a dual-use arrangement, a model actively identified as a primary pathway for off-grid SMR deployment in Canada's national strategy (31). To facilitate these partnerships, federal financial instruments, including loan guarantees and low-interest financing through the Canada Infrastructure Bank (CIB), must be deployed to de-risk private investment, building on the CIB’s established precedent of financing major nuclear infrastructure (32). Finally, integrating robust carbon market mechanisms can transform emission reductions into tangible financial assets. Displacing millions of litres of diesel will generate substantial carbon offset credits, which can be monetised and reinvested directly into the community, creating a self-sustaining economic loop that funds further local development (33).

Conclusion: Securing Canada’s Energy Future

Canada’s path to net-zero requires strategy diversification. Given Canada’s regional differences, expanding traditional grids is not enough of a solution to ensure an equitable and resilient energy future. While this solution works in the near-North, it fails in the far-North/Arctic due to extreme weather, climate vulnerability, and geography. Simultaneously, the increased demand for electricity, critical mineral development and digital infrastructure are placing added pressures to grids in the south of the county that hinder their capacity to meet the energy demands of northern regions and territories.

Diversifying the energy transition is therefore key. A solution is installing small modular reactors and microgrids in communities, ensuring connectivity across remote areas. It is also essential to integrate Indigenous partnership into action plans, where consent ensures that energy solutions align with local priorities while ensuring long-term sustainability.

By aligning technology deployment with inclusive governance, Canada can secure a resilient and equitable net-zero future where Indigenous consent is at the core of decision-making.

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